Signal Extraction in the Salt Phase of the SNO Detector

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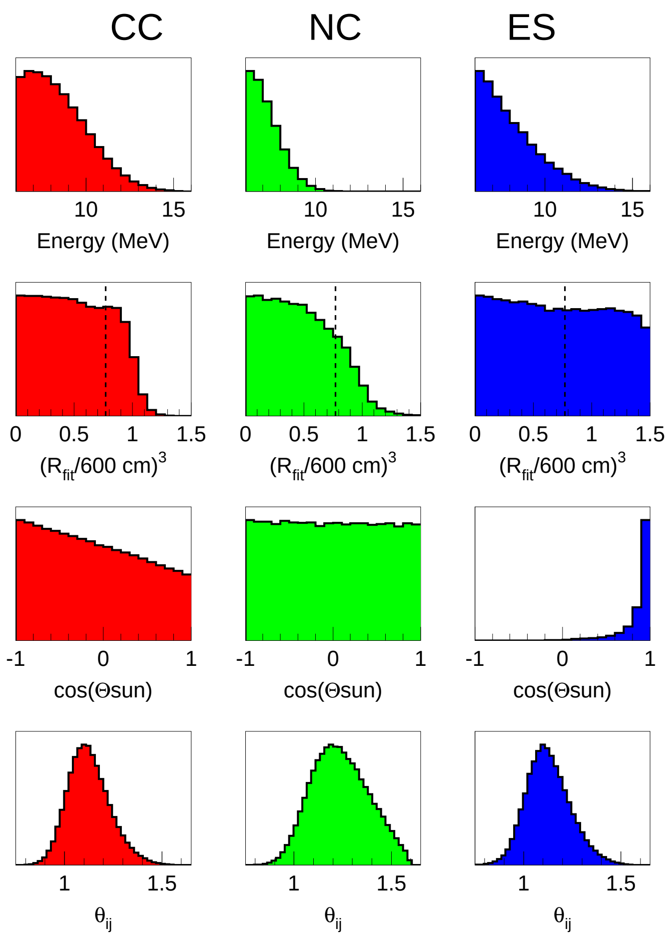

FIG. 1: Shown here are the energy, reconstructed radius, $\cos(\theta_{sun})$, and isotropy distributions for CC, NC, and ES interactions. The dashed line on the R plots indicates the boundary of the fiducial volume.

The SNO detector is a large volume heavy-water Cerenkov detector. Inside of the 1 kton heavy water target of the SNO detector, there are three neutrino interactions which can occur:

$$\nu_x + e^- \Rightarrow \nu_x + e^- \text{ (ES)} \quad (1)$$

$$\nu_e + d \Rightarrow p + p + e^- \text{ (CC)} \quad (2)$$

$$\nu_x + d \Rightarrow \nu_x + p + n \text{ (NC)} \quad (3)$$

The first of these reactions, given by Equation 1, is an elastic scattering (ES) interaction. It should be noted that this interaction can occur for any neutrino flavor, ν_x, but the cross section is 6 to 7 times greater for ν_e. The scattered electron direction is highly correlated with the incident neutrino direction. The charged-current (CC) reaction, Equation 2, is unique due to the fact that it can occur for only ν_e. Here the electron energy is well correlated with the neutrino energy. The final reaction, the neutral-current (NC) reaction of Equation 3, is extremely important because it is equally sensitive to all neutrino flavors and can measure the total solar neutrino flux, which can provide evidence that neutrinos are undergoing flavor transformation. During the second phase of the SNO detector, in which two tonnes of salt (NaCl) were mixed into the heavy water, these neutrons will typically capture on Cl, resulting in a cascade of gamma rays with a total energy of 8.6 MeV.

It is not possible to distinguish these neutrino interactions from one another on an event by event basis. However, we can look at a large sample of these events and deduce how many events of each type were present due to the different behaviors of each signal. Four parameters which can be used to distinguish the events from the various neutrino signals are 1) the energy, 2) the reconstructed radial position, 3) the isotropy of the light pattern seen (defined by the mean angle between phototube pairs θ_{ij}), and 4) the angle between the reconstructed event direction and the Sun's position in the sky. Figure 1 shows what these variables look like for the three neutrino signals.

To determine the number of neutrino events in the detector, a simultaneous maximum likelihood fit to the energy, R_{fit}, $\cos(\theta_{sun})$, and isotropy distributions distribtions will be performed. Here the fit determines 3 parameters: the numbers of CC, NC, and ES events in the dataset. Since the CC reaction electron energy is highly correlated with the energy of the neutrino and neutrino oscillations can distort the neutrino energy spectrum, the fit will be performed without constraining the energy distribution of the CC reaction. The extraction of the neutrino signals in the full salt dataset of SNO is the focus of the upcoming PhD dissertation by A. Marino.